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(54) Optical surface testing

(57) A device for the optical testing of the surface of an object 12, particularly a compact disc, in which the surface is illuminated by at least one upper light source 51 from above and/or by means of a lower light 41 from the side at a sharp angle with respect to the surface. There is at least one light-sensitive receiver 16, e.g. a CCD camera, for receiving the reflected and/or scattered light coming from the surface. At least one lens arrangement 19 between the surface and the objective 20 of the light-sensitive receiver, converges light rays from its focal point into substantially parallel light rays, and at least one beam splitter means 47 is provided in the beam path between the lens arrangement and the objective, in order to generate at least two focal points of the lens arrangement. The upper light source is arranged at one focal point and the objective is arranged at the other focal point of the lens arrangement.

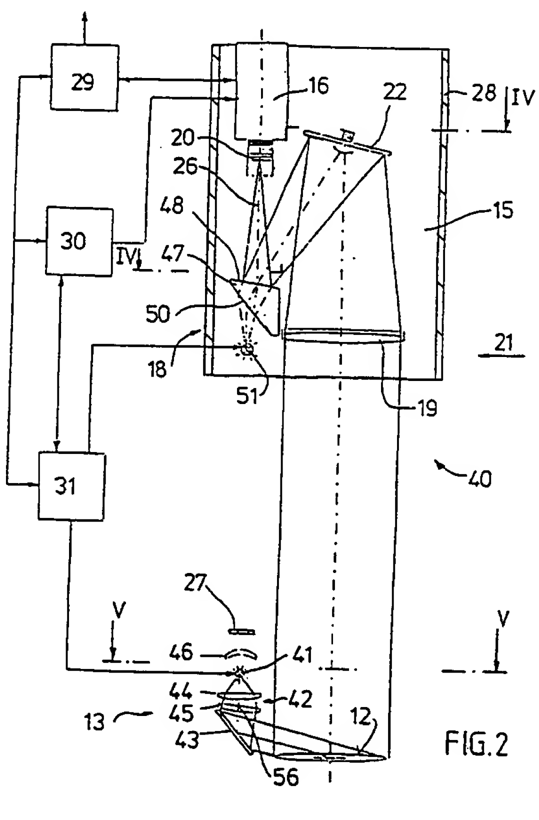

FIG.2

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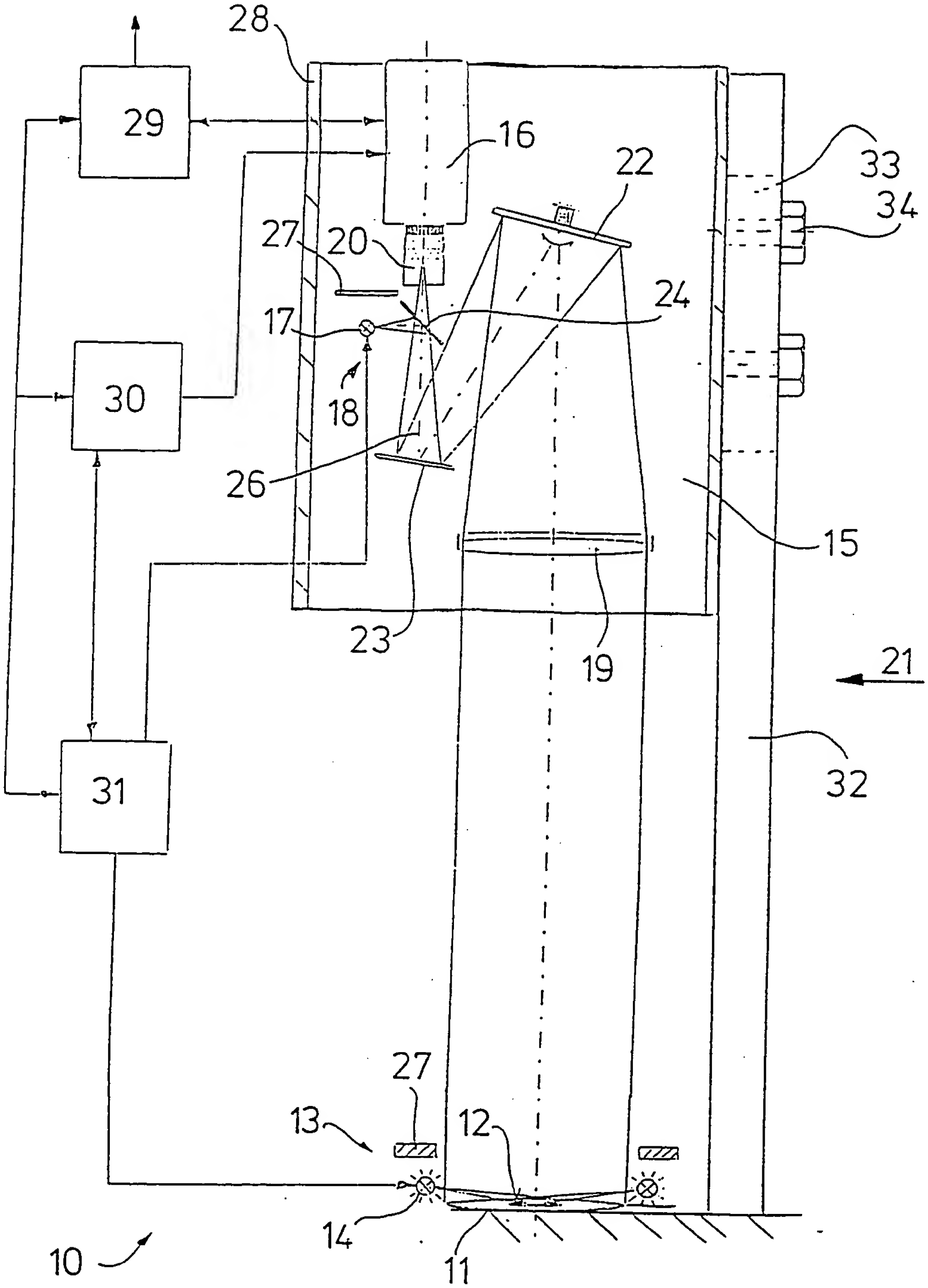
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FIG.1

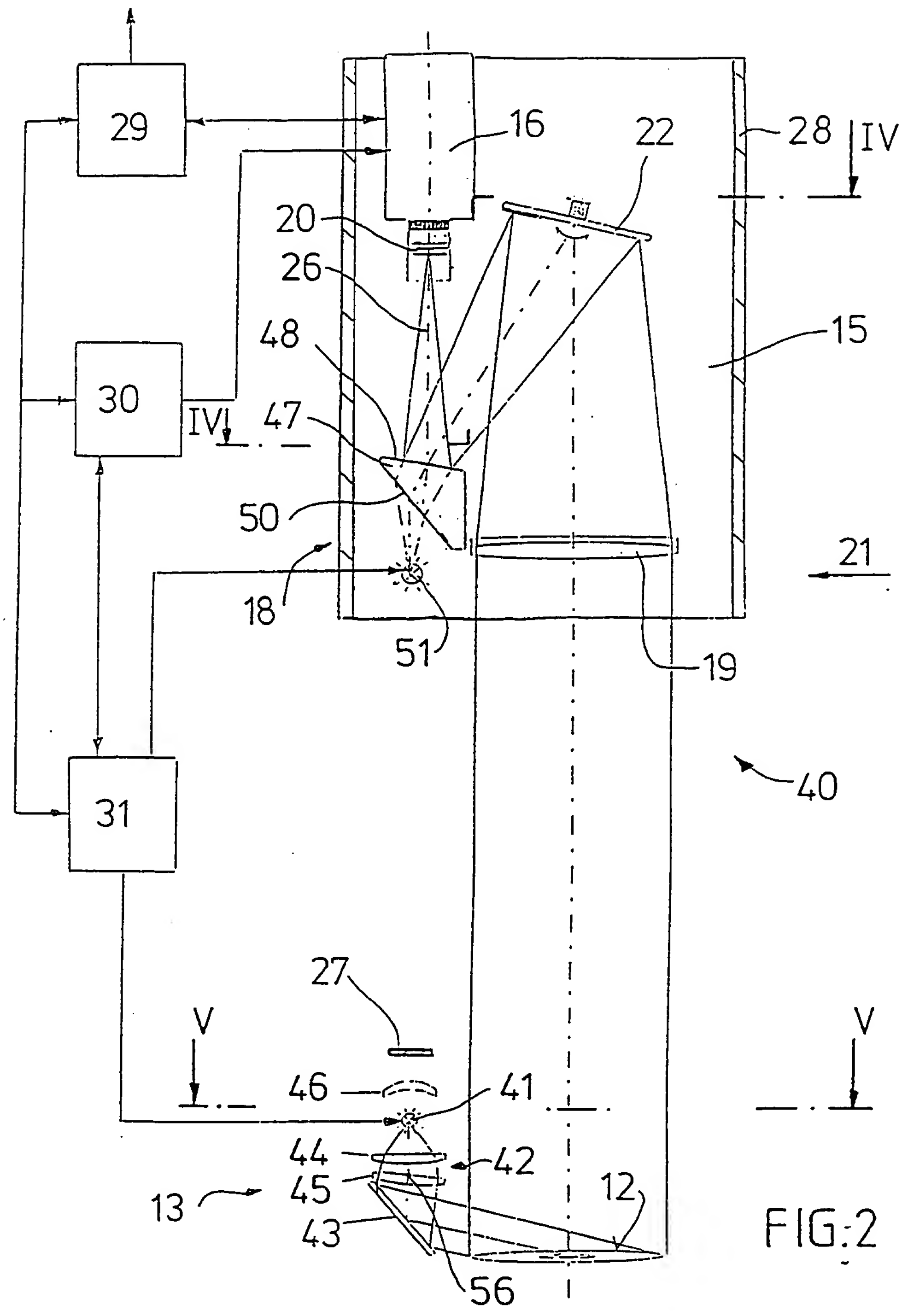
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FIG:2

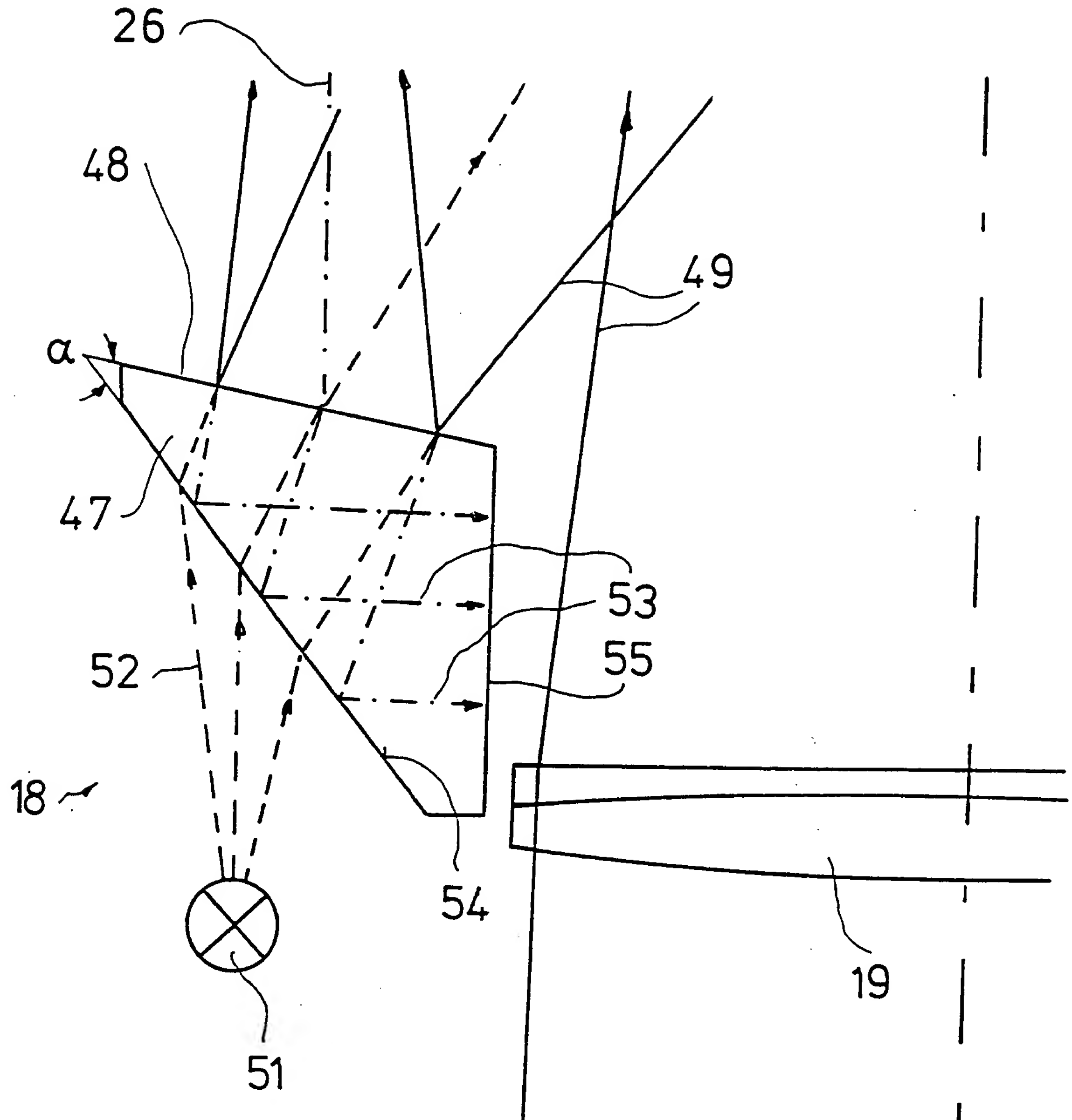

FIG.3

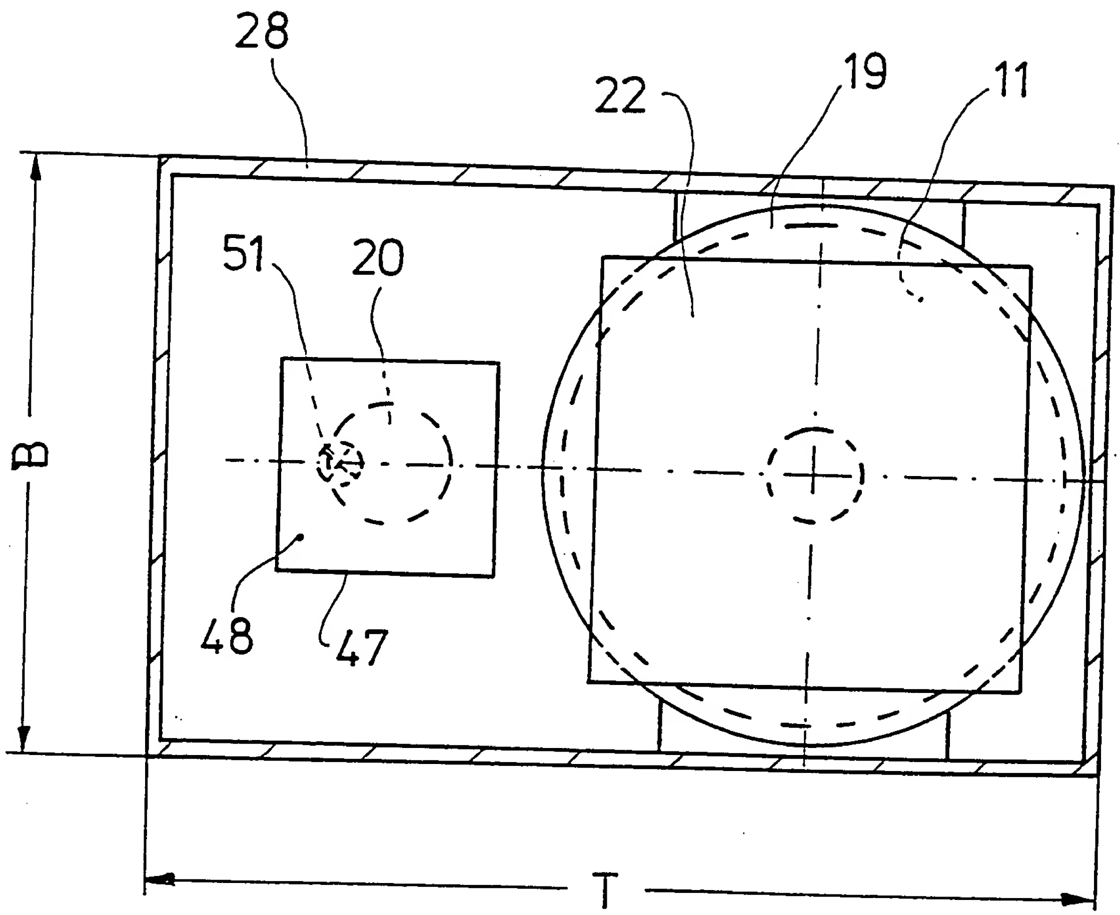

FIG.4

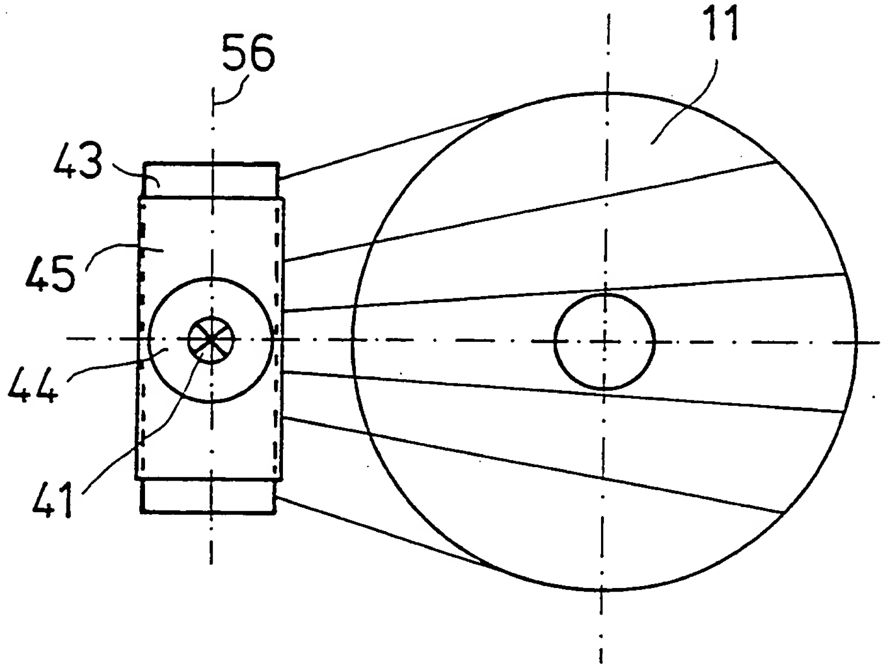

FIG.5

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OPTICAL TEST DEVICE

The invention relates to a device for the optical testing of a surface of an object in which the surface can be illuminated by at least one light source from above by means of an upper light and/or by means of a lower light from the side at a sharp angle with respect to the surface. Such apparatus has at least one light-sensitive receiver for receiving the reflected and/or scattered light coming from the surface. The invention relates particularly, but not exclusively to the optical testing of the printed surface of a compact disc, upon which the following description concentrates. Nevertheless, the suitability of the invention for other surfaces will be recognised.

CDs have recently become increasingly popular as sound media for home use because of the high potential sound quality, and as pure data media in data processing because of the high potential data density. They are therefore a mass-market product, but have to meet high to very high quality demands, particularly when used as pure data media.

Generally speaking a CD comprises a circular disc, multi-layered in cross-section, with a central tap hole for fitting and centring in a player. From the bottom, i.e. viewed from the read side of the player, upwards the CD consists of a transparent plastic layer which contains all the data in the form of pits, a thin metal layer, generally of aluminium, for metallizing the plastic layer, and a thin lacquer layer which is usually hardened by UV light, for protecting the metal layer. The imprint, the so-called label, to provide information to the consumer, is then applied to the UV lacquer layer by means of known printing processes.

In the radial direction, in a CD several coaxial, circular regions which move outwards from the tap hole can be distinguished. Directly at the tap hole is the region used to fit the CD in the player. Adjoining this is a region in which the so-called ident code, by means of which the CD can be

unequivocally identified, is impressed. There then follows the region used for the actual data storage. If the CD is recorded up to its maximum storage capacity the region ends directly on the outer edge region. Otherwise the so-called lead-out or a reflective strip is arranged between the edge region of the CD and the data region.

In the manufacturing process a polycarbonate blank is initially produced by the die-casting method, wherein all data are already impressed by the die. One surface of the blank is then provided with the metallic reflective layer by the sputter process and sealed with the lacquer layer. In this process the CD is centrifuged in order to achieve a uniform distribution of the lacquer layer and as thin a layer as possible. The label is then printed on the CD.

In principle the label is of no importance to the function of the CD because a CD is read from the underside. For the consumer, however, a perfect label is often a criterion for perfect playback of the CD so that it is necessary to produce a faultless imprint on the surface of the CD. In contrast the UV lacquer layer on a CD must always be perfect because otherwise there is the risk of the underlying metal layer oxidizing prematurely, which could cause reading errors. Processes with which the surface of the CD, i.e. the label and optionally also the UV lacquer layer, can be tested are therefore required. As a test of each CD must be performed after manufacture it is necessary to incorporate the test method for the upper side of the CD into the continuous production process. This means that there is often only a limited testing time available for the test process.

Generally speaking an optical device is used for testing the printed surface of the CD, with which the surface of the CD is photographed by a light sensitive receiver, generally an electronic CCD camera, in the top view from above. In a data processing unit the actual image taken is compared with a

previously calibrated desired image of a perfect surface with certain test criteria. Any deviation is then detected as a fault and the CD is graded according to the size and nature of the deviation. In a known device the camera is exposed once, whereas the CD is simultaneously illuminated both from above with the so-called upper light and with the so-called lower light from the side at a sharp angle with respect to the surface. The camera receives the upper light reflected from the surface and the lower light scattered on the surface.

Regarding the incorporation of the test device a problem arises in that there is usually only restricted installation space available. In particular it is necessary for handling means to be able to move the object, the CD for example, to the test device and away from it. Traditionally the upper light is therefore deflected onto the surface via a semi-reflecting mirror which is arranged above the free space for the handling means. Because of the path of the rays reflected on the surface of the CD, which must be recorded by the light-sensitive receiver in their entirety, the semi-reflecting mirror has a surface which is approximately four times the size of the CD and hence has approximately twice the diameter (the diameter of a CD is approx. 120 mm). The test device therefore requires a great deal of space in the lateral direction, wherein the lateral boundary of the device projects over the edge of the CD by at least half the diameter of the CD.

This causes problems, particularly with so-called twin units. In twin units, two CDs are conveyed to the same processing steps at the same time. In such units the CDs are very close together, with an axis spacing of only approx. 135 mm, for example. As a rule, therefore, there is no room for an upper light configured in this way, so that compromises must be accepted as regards the illumination.

On the other hand the handling means for the object, such as the CD, are frequently obstructed by the lower light which surrounds the CD in the form of a ring along the circumference at a lateral distance above the surface. In this case the object is in a kind of hollow so that the handling means have to make relatively complicated movements in order to grasp the object. With an annular lower light there is also the problem that because of the greater radial space requirement along the circumference of the CD an arrangement in twin units is not straightforward, so that here also compromises must be accepted as regards the illumination by the lower light.

An object of the invention is therefore to design a device of the above-mentioned kind in such a way that it has smaller dimensions compared with the prior art and can therefore be incorporated into existing manufacturing plants for the object in question without problems. It should also be possible in particular to incorporate the device into twin units.

According to the invention the object is achieved in that at least one lens arrangement, which concentrates light rays diverging from its focal point into substantially parallel light rays, is provided in the beam path between the surface and the objective of the light-sensitive receiver, that at least one beam splitter means is provided in the beam path between the lens arrangement and the objective, in order to generate at least two focal points of the lens arrangement, wherein the light source for the upper light is arranged in the one focal point in order to illuminate the surface with substantially parallel light rays, and the objective is arranged in the other focal point of the lens arrangement in order that the substantially parallel light rays of the light coming from the surface are projected directly or indirectly onto the objective of the light-sensitive receiver. This arrangement has the advantage that because of the lens arrangement the upper light shines on the surface with at least approximately parallel rays and the reflected rays are

also substantially parallel but in the opposite direction, so that the use of the large-sized mirror previously required to introduce the upper light is no longer needed. This means that the device is substantially less wide and can also be used, for example, in twin units without problems. The device of course has corresponding cover means to prevent direct illumination of the light-sensitive receiver by the light source for the upper light. This can also be achieved in that by means of the beam splitter means, a beam splitting takes place in that the focal points are so arranged that the light from the light source for the upper light can only reach the light-sensitive receiver by means of reflection on the surface, without exposing it directly.

An advantageous embodiment provides that the lens arrangement has an achromatic lens. This has the advantage that the surface can be relatively accurately represented on the objective.

The parallel beam path creates a telecentric structure between the lens arrangement and the surface so that the distance between the surface and the superstructure of the device, which carries the upper light, the light-sensitive receiver and the like, can be varied in certain regions without problems, particularly without disturbing the optics in the superstructure. This means that an advantageous, flexible adaptation of the device to existing production devices with handling means which operate and/or are dimensioned in different ways is possible.

A further advantageous embodiment of the invention provides that at least one mirror element is provided in the beam path of the light coming from the surface, between the lens arrangement and the light-sensitive receiver, in order to deflect the light coming from the surface at least once before it enters the light-sensitive receiver. Particularly where an achromatic lens is used, the fact that its focal length is

usually relatively long presents a problem. The height can be advantageously reduced by means of at least one beam deflection prior to entry into the light-sensitive receiver.

Another appropriate embodiment provides that a second mirror element is provided in the beam path of the light coming from the surface in order to deflect the light twice prior to entry into the light-sensitive receiver, and that the light-sensitive receiver is aligned in such a way that its optical axis is laterally offset and runs substantially parallel to the beam path between surface and lens arrangement. This arrangement permits a particularly compact construction, since the height of the superstructure, which carries the upper light, the lens arrangement and the light-sensitive receiver, can now be barely higher than the height of the light-sensitive receiver. By means of the double beam deflection the light-sensitive receiver can also be arranged very close to the optical axis of the lens arrangement, so that the depth of the device is increased only unsubstantially.

An appropriate embodiment provides that the beam splitter means has a semi-reflecting mirror. The semi-reflecting mirror is aligned in such a way that the light emitted by the light source for the upper light is reflected at least partially towards the lens arrangement without directly reaching the receiver. The light coming from the surface partially passes through the mirror in order to expose the light-sensitive receiver. In principle other beam paths are also possible. In this case the semi-reflecting mirror can be arranged at any point on the beam path between the lens arrangement and the light-sensitive receiver. Provision can be made for the semi-reflecting mirror to be placed closer to the light-sensitive receiver than to the lens arrangement. Because of the convergent beam path present behind the lens arrangement, the size of the mirror can be the smaller, the closer to the light-sensitive receiver it is arranged. In particular the dimensions of the mirror can be smaller than

the dimensions of the lens arrangement, so that a widening of the device is not necessary because of a beam splitter means designed in this way.

A further embodiment of the invention provides that at least one optical prism is provided as beam splitter means. Advantageously an optical prism can have a multiplicity of lateral surfaces which are semi-reflecting, totally reflecting and solely light-refracting, in a very limited space, so that the desired requirement, viz. to produce two focal points of the lens arrangement without the light source being in a direct beam connection with the light-sensitive receiver, can be met. In particular this means that a small construction can be achieved.

A preferred embodiment of the invention therefore provides that the prism has a first lateral surface which is in the form of a semi-reflecting mirror and is aligned in such a way so as at least partially to reflect the light coming from the surface in the direction of the light-sensitive receiver, and that the prism has a second lateral surface, on whose side facing away from the first lateral side the light source for the upper light is arranged and which runs at an angle to the first lateral surface, which angle is selected in such a way that the light rays of the light source are deflected in the direction of the lens arrangement by refraction and those light rays which would emanate from the light-sensitive receiver would undergo a total reflection at the inner boundary surface of the second lateral surface. The angle should be selected according to the position of the prism in the beam path, the focal length of the lens arrangement and the material. The corresponding conditions will, however, be familiar to the person skilled in the art and therefore require no further explanation. Because of the total reflection the light-sensitive receiver can no longer directly receive the light from the light source, so that this lateral surface of the prism acts like a cover of the light source in

this direction. Through the use of such a prism, the upper light can be introduced into the beam path without problems, without a direct exposure of the light-sensitive receiver. A very compact construction can also be advantageously achieved.

It can be appropriate if the first lateral surface of the prism in the form of a semi-reflecting mirror forms the second mirror element. This means that the beam splitting on the one hand and the introduction of the upper light on the other hand can be achieved by means of a single structural element in an advantageous and space-saving manner.

Because of the advantageous illumination of the surface with parallel rays and the concentration of the parallel rays coming from the surface, which can be both reflected light from the upper light and scattered light from the lower light, provision can be made for the dimensions of the optically effective area of the lens arrangement parallel to the surface to correspond at least to the dimensions of the surface under test of the object. In principle, however, lens arrangements with larger dimensions than the surface under test are advantageous because the effects caused by tilting can be reduced by this means. In addition there is a guarantee in every case that edge regions of the surface are also illuminated sufficiently and the light coming from these regions is projected completely into the objective of the light-sensitive receiver.

The invention also relates to a device for the optical testing of a surface of an object, particularly a CD, in which the surface can be illuminated by at least one light source by means of an upper light from above and/or by means of a lower light from the side at a sharp angle with respect to the surface and which has at least one light-sensitive receiver for receiving the light reflected and/or scattered by the surface, wherein the lower light comprises optical means which have at least one lens arrangement in order to concentrate the

light emitted by the light source for the lower light in such a way that the surface can be illuminated from only one side of the object with a substantially constant light intensity starting from the edge facing the lower light to the edge of the surface facing away from the lower light. Advantageously the device can also be provided with the features of the above-mentioned embodiments. By means of this design of the lower light, advantageously it is possible to minimize the width of the device in the lower section also, since the dimensions of the lower light can now be smaller than the width of the object, smaller than the diameter of the CD, for example. By means of the illumination from one side only, objects which are very close together or even immediately adjacent can also be illuminated with uniform light intensity over the entire surface. This further simplifies incorporation into a twin unit.

A further advantage is that the object now lies virtually completely freely on the mounting device so that the handling means can grasp the object without problems. This advantageously increases the flexibility of the incorporation of the device according to the invention into existing equipment.

Particularly when the telecentric arrangement is simultaneously used, an optical test device can be provided which has the highest degree of flexibility as regards adaptation to existing production devices in addition to a small space requirement.

An appropriate embodiment provides that the optical means for the lower light has at least one spherical convergent lens and one cylindrical lens. The lenses can be dimensioned in such a way that the surface can be illuminated by slightly divergent light rays viewed from the top and by substantially parallel light rays viewed from the side. A uniform illumination of the surface can thus be achieved with simple means. The

sequence of the lenses is arbitrary in principle. It is also possible to use combined lenses, which have a spherical surface on one side and a cylindrical one on the other. The desired beam path can also be generated by a Fresnel lens. When selecting the lenses care should be taken to ensure that the light emitted by the light source is concentrated on the surface as completely as possible without illuminating adjacent regions. This can increase the luminous efficacy.

An advantageous embodiment provides that the cylindrical lens can be pivoted about a longitudinal axis perpendicular to the optical axis. By this means the so-called lens errors can be utilized in order further to improve the uniformity of the lighting of the entire surface in an advantageous manner.

It can also be appropriate that at least one mirror element is provided between the light source for the lower light and the surface. The mirror element can be aligned in such a way that the optical axis of the lenses runs substantially perpendicular to the surface of the object so that the depth of the device in the region of the lower light, in which there is generally a shortage of space around the object, can be reduced in an advantageous manner.

Provision can also be made for the lower light and/or the upper light to emit diffuse light. This can increase the uniformity of illumination both by the upper light and by the lower light.

The invention will be described in greater detail below by way of example and with reference to the accompanying diagrammatic drawing in which:

Fig. 1 is a side view of a device according to the invention,

Fig. 2 is a side view of a device according to a further embodiment of the invention,

Fig. 3 is a side view of a prism in an enlarged representation,

Fig. 4 is a section according to IV-IV in Fig. 2, and

Fig. 5 is a top view section along V-V in Fig. 2.

The device 10 for the optical testing of a surface, of a CD for example, which is shown in Fig. 1 has a generally columnar vertical structure to which the individual functional elements are secured. For reasons of clarity the retaining devices required to secure the individual functional elements are not shown in the drawing.

In its lower section the device 10 has a mounting device, which is also not shown, for receiving and centring a CD 11 for the test. From the side the surface 12 of the CD 11 can be illuminated with light with a sharp angle of incidence by means of a lower light 13. More specifically the arrangement is such that the lower light has an annular light source 14 which surrounds the CD 11 laterally above the surface 12 in the circumferential direction. Provision can also be made for the lower light 13 to comprise several individual light sources arranged at a distance from one another in the circumferential direction.

Above the CD 11 a superstructure 15 of the test device 10 is provided in which a light-sensitive receiver 16 for photographing the surface 12 of the CD 11 in the top view, a light source 17 for an upper light 18 and a lens arrangement 19 for aligning the light rays onto the surface 12 and for concentrating the reflected and/or scattered light coming from the surface 12 into the objective 20 of the light-sensitive receiver 16 are arranged. By means of the lens arrangement 19, the light emitted from the upper light 18 is aligned parallel on the surface 12 and at the same time the light coming from the surface 12 is projected onto the objective 20 of the light-sensitive receiver 16. The width of the device 10 perpendicular to the drawing plane (in the direction of the

arrow 21) can be reduced because of the substantially parallel beam path between the lens arrangement 19 and the surface 12 of the CD 11. As shown in Fig. 4 for example, width B is substantially determined by the dimensions of the lens arrangement 19 and is therefore only unsubstantially larger than the width of the surface or the diameter of the CD 11. The lens arrangement 19 can comprise an achromatic lens for example.

In the direction in which the light radiates from the surface 12 the light is deflected twice, through a first plane mirror element 22 and through a second plane mirror element 23, before it enters the objective 20 of the light-sensitive receiver. This beam deflection enables the structural height to be reduced. This is appropriate because the focal length, of an achromatic lens for example, cannot be arbitrarily small, so that the device would be relatively tall without the beam deflection. The beam deflection can be dispensed with, however, if there is sufficient space towards the top of the manufacturing device of the object in question. By means of the beam deflection the light-sensitive receiver 16 is aligned in such a way that its optical axis 26 runs substantially parallel to the parallel-aligned rays between the surface 12 and the lens arrangement 19. This alignment only brings about a greater depth (depth T in Fig. 4) of the superstructure, however, whereas the width of the superstructure, which is substantially determined by the diameter of the lens arrangement 19, is not changed.

To align the upper light 18 onto the lens arrangement 19 a beam splitter means is provided which takes the form of a semi-reflecting mirror 24 in the embodiment shown in Fig. 1. More specifically the arrangement is such that the semi-reflecting mirror 24 is aligned in the beam path in such a way that the light of the light source 17 for the upper light 18 is partially reflected in the direction of the lens arrangement 19 whereas a part of the light coming from the surface 12 passes through the mirror 24 and exposes the light-sensitive receiver.

To prevent misunderstandings it should be noted that a deviation in the direction of an element should also be understood to mean that behind this optical means which brings about this deviation the light beam can of course experience further deflections and/or deviations by other optical means. Consequently a beam path can also correspond to a line deflected many times.

The semi-reflecting mirror 24 means that the lens arrangement 19 can fix rays on two focal points. This is required on the one hand because the light source 17 for the upper light must be at least approximately in a focal point of the lens arrangement 19 for an optimum illumination by the upper light. On the other hand, to achieve the telecentric structure the objective 20 of the light-sensitive receiver 16 must be in a focal point of the lens arrangement 19. The use of the semi-reflecting mirror means that two focal points of the lens arrangement are generated and that the focal points have no direct optical connection, i.e. that a light beam from the light source 17 can only reach the light-sensitive receiver 16 via the surface 12 of the CD 11.

In the embodiment shown in Fig. 1 the semi-reflecting mirror 24 is arranged between the second mirror element 23 and the light-sensitive receiver 16, i.e. in the beam path closer to the light-sensitive receiver than to the lens arrangement. Because of the convergent beam path between lens arrangement 19 and the light-sensitive receiver the semi-reflecting mirror 24 can be relatively small in size. Corresponding cover elements 27 are provided between the light source 17 for the upper light 18 and the objective of the light-sensitive receiver 16 in order to avoid a direct exposure. Such cover elements 27 are also provided at corresponding points for the light source 14 for the lower light 13. Provision can also be made for the light sources to be provided with corresponding cover means which are not shown in order to emit light in a preferred direction only.

The superstructure 15 is surrounded by a sleeve-like cover element 28 to prevent the ambient area from being dazzled by the upper light 18 and the light-sensitive receiver 16 from being influenced by ambient light. This sleeve-like cover element 28 can have a rectangular cross-section, the inner width of which at least corresponds to the external diameter of the lens arrangement 19, so that no tangible increase in the width can be expected because of the sleeve-like cover element 28.

The light-sensitive receiver 16 is connected to a data processing unit 29 which compares the actual images taken with at least one already calibrated image. Furthermore a first and a second control means 30 and 31 are provided to set the exposure time of the light-sensitive receiver 16 and/or the illumination of the surface by the upper light 18 and/or the lower light 13. The first control means 30 is connected to the second control means 31 in order to permit synchronization between the lighting and the light-sensitive receiver.

Provision can, for example, be made for two images of the surface to be taken within one test period in order to prevent a contrast weakening in the images in question, which could take place if there was simultaneous illumination from the upper light and the lower light. Provision can be made for the upper light to take the form of a flashlight whereas the lower light is a constant light. During the flash the light-sensitive receiver, generally a CCD camera, is switched into the so-called shutter mode so as to set the correspondingly short exposure time. The flashlight causes a substantially stronger exposure of the camera so that the simultaneous exposure with the continuous lower light is barely effective in the photograph taken. Two images of a surface can thus be produced simply and in a very short time indeed.

By means of the parallel beam path between the lens arrangement 19 and the surface 12 of the CD 11 in the form of a telecentric structure it is possible to vary the distance between the superstructure 15 and the surface of the object

within certain limits without changing the optics in the superstructure. At least one support 32, which has at least one oblong hole 33 for example, in order to hold the superstructure 15 with clamping elements 34, bolts for example, in a movable manner can be provided for this purpose.

Fig. 2 provides a further embodiment of an optical test device according to the invention. The mode of operation and the columnar structure of this device 40 substantially corresponds to that of the device 10 of Fig. 1, and identical elements are provided with identical reference numerals.

In the embodiment shown in Fig. 2 the lower light 13 is arranged on one side of the CD only. The lower light has a light source 41, the light rays from which are directed onto the surface 12 of the CD 11 through a lens arrangement 42 and a mirror 43. More specifically the arrangement is such that a round convergent lens 44 and a cylindrical lens 45 are arranged in the direction of the rays from the light source 41 in order to illuminate the surface 12 with a pencil of rays, which has slightly divergent rays viewed from above and substantially parallel rays viewed from the side, at a sharp angle of incidence. The cylindrical lens 45 is tiltably mounted about a longitudinal axis 56 perpendicular to the drawing plane. This means that the cylindrical lens 45 can be aligned in such a way that the entire surface can be illuminated with substantially identical light intensity by utilizing the lens errors. A concave mirror 46 can also be provided behind the light source 41 to increase the luminous efficacy.

According to the space available on the one side of the object, in principle it is of course also possible that a lens of the lens arrangement is larger than the diameter of a CD, for example, so that the surface can be illuminated with slightly convergent rays. This has the advantage that the uniformity of the light distribution over the surface can be improved.

As can be seen in Fig. 5 in particular, the width of the test device can be reduced in the lower section also by the arrangement on only one side of the object under test. In particular, however, the CD is substantially freely accessible, for example, so that it is possible for the handling means to move to grasp the CD without hindrance.

In the device 40 shown in Fig. 2 the upper light 18 is brought towards the lens arrangement 19 by means of an optical prism 47. The optical prism 47 is shown in an enlarged representation in Fig. 3.

More specifically the arrangement is such that the optical prism 47 has a semi-reflecting mirror surface 48 which is aligned according to the mirror element 23 of the device 10 in Fig. 1. The light rays 49 coming from the surface 12 and concentrated by the lens arrangement 19, and which are shown by solid lines in Fig. 3, are therefore partially reflected in the direction of the light-sensitive receiver in corresponding manner.

The prism 47 also has a second lateral surface 50 on whose side facing away from the semi-reflecting mirror surface a light source 51 for the upper light is arranged. This second lateral surface 50 runs at an angle α to the semi-reflecting mirror surface 48 such that the light rays 52, shown by dashed lines in Fig. 3, emanating from the light source 51 run precisely opposite to the light rays 49 coming from the surface, through refraction at the second lateral surface and through further refraction at the semi-reflecting mirror surface. In this case the light source 51 is arranged in the second focal point of the lens arrangement 19 produced by the prism 47 acting as beam splitter means.

Furthermore the angle α is selected in such a way that the light-sensitive receiver cannot see directly into the light source 51. This means that light rays 53 which would emanate from the light-sensitive receiver 16 experience total reflection at the inner boundary surface 54 of the second

lateral surface 50. The setting of such an angle is possible because a light beam coming from the light source must impinge on the second lateral surface 50 at a particular angle in order to obtain the desired beam path by refraction at the two sides. A light beam coming from the light-sensitive receiver is initially refracted at the first side and impinges on the second lateral surface 50 at a different angle from that set for the light source. Depending on the position of the first side of the prism in the beam path, angles can therefore be set in such a way that a light beam coming from the light source experiences no total reflection at all at the second side whilst a light beam coming from the light-sensitive receiver is totally reflected at this side.

The rays 53, shown in Fig. 3 by dot-and-dash lines, which are totally reflected at the inner boundary surface 54, then impinge on a third side 55 of the prism which is blackened for example. A blackening or other darkening of this side also has the advantage that any influence from diffused light can be avoided. By a corresponding setting of the angle α between the lateral surfaces 48 and 50, therefore, a direct illumination of the light-sensitive receiver by the light source 51 for the upper light can be prevented.

The angle α should be selected according to the local circumstances, i.e. particularly the position of the prism in the beam path and the material used for the prism. The person skilled in the art will know how to determine the angle in order to meet the requirements and so there is no need for further explanation of it. For reasons of completeness it should be noted that the particular light rays 49, 52 and 53 run over each other in certain sections. Only one ray is ever shown, however, for reasons of clarity.

The depth of the device can be further reduced through this design of the upper light, as the light source 51 for the upper light 18 can be in the immediate vicinity of the optical axis 26 of the light-sensitive receiver 16. Because of the special design of the optical prism 47, however, direct

exposure by the upper light is reliably avoided, since by means of the total reflection of the imaginary rays 53 at the inner boundary surface 54 of the second lateral surface 50 this surface acts like a cover element.

The support 32 for the movable arrangement of the superstructure 15 is not shown in Fig. 2 for reasons of clarity. It is, however, also possible of course to provide the device 40 with a support 32 of this kind. It is also self-evident that the different structural types of the upper light 18 or the lower light 13 can be exchanged in the devices 10 and/or 40.

The drawing and the description have not described the individual angles to be maintained in greater detail because they depend in particular on the different dimensions of the various elements. The person skilled in the art will be able to determine and set the precise alignments of the elements in question with the aid of the description, without needing further explanation.

It is evident that the device according to the invention can be built in an extremely compact manner. By illuminating the surface by means of parallel light rays aligned substantially perpendicular to it by the upper light and then concentrating the reflected rays into the objective by means of the lens arrangement, the width of the device need only be unsubstantially wider than the surface under test. Despite this the surface under test is completely and uniformly illuminated by the upper light. A complete and uniform illumination of the surface can also be achieved by means of the extremely compact lower light, so that an optimum image of the entire surface to be tested, such as that of a CD, can always be obtained.

Claims

1. A device for the optical testing of a surface of an object, in which the surface can be illuminated by at least one light source from above by means of an upper light and/or by means of a lower light from the side at a sharp angle with respect to the surface and which has at least one light-sensitive receiver for receiving the reflected and/or scattered light coming from the surface, including at least one lens arrangement, which concentrates light rays diverging from its focal point into substantially parallel light rays, in the beam path between the surface and the objective of the light-sensitive receiver, and at least one beam splitter means in the beam path between the lens arrangement and the objective, in order to generate at least two focal points of the lens arrangement, and wherein the light source for the upper light is arranged at least approximately in the one focal point in order to illuminate the surface with substantially parallel light rays, and the objective is arranged in the other focal point of the lens arrangement in order that the light coming from the surface is projected directly or indirectly onto the objective of the light-sensitive receiver.

2. A device according to Claim 1 wherein the lens arrangement has an achromatic lens.

3. A device according to Claim 1 or Claim 2 including at least one mirror element in the beam path of the light coming from the surface, between the lens arrangement and the light-sensitive receiver, in order to deflect the light coming from the surface at least once before it enters the light-sensitive receiver.

4. A device according to any preceding Claim including a second mirror element is provided in the beam path of the light coming from the surface in order to deflect the light

twice prior to entry into the light-sensitive receiver, and that the light-sensitive receiver is aligned in such a way that its optical axis is laterally offset and runs substantially parallel to the beam path between the surface and the lens arrangement.

5. A device according to any preceding Claim wherein the beam splitter means has a semi-reflecting mirror which is arranged in the beam path between the lens arrangement and the light-sensitive receiver.

6. A device according to any preceding Claim wherein the semi-reflecting mirror is arranged in the direction of the beam closer to the objective than to the lens arrangement.

7. A device according to any preceding Claim wherein at least one optical prism is provided as beam splitter means.

8. A device according to any preceding Claim wherein the prism has a first lateral surface which is in the form of a semi-reflecting mirror and is aligned in the beam path in such a way as at least partially to reflect the light coming from the surface directly or indirectly in the direction of the light-sensitive receiver, and the prism has a second lateral surface, on whose side facing away from the first lateral side the light source for the upper light is arranged and which runs at an angle to the first lateral surface, which angle is selected in such a way that the light rays of the light source are deflected directly or indirectly in the direction of the lens arrangement by refraction and those light rays which would emanate from the light-sensitive receiver would undergo a total reflection at the inner boundary surface of the second lateral surface.

9. A device according to any preceding Claim wherein the first lateral surface of the prism in the form of a semi-reflecting mirror forms the second mirror element.

10. A device according to any preceding Claim wherein the dimensions of the optically effective area of the lens arrangement parallel to the surface correspond at least to the dimensions of the surface under test of the object.

11. A device for the optical testing of a surface of an object in which the surface can be illuminated by at least one light source by means of an upper light from above and/or by means of a lower light from the side at a sharp angle with respect to the surface and which has at least one light-sensitive receiver for receiving the light reflected and/or scattered by the surface, wherein the lower light comprises optical means which have at least one lens arrangement in order to concentrate the light emitted by the light source for the lower light in such a way that the surface can be illuminated from only one side of the object with a substantially constant light intensity starting from the edge facing the lower light to the edge of the surface facing away from the lower light.

12. A device according to Claim 11 wherein the optical means for the lower light has at least one convergent lens and one cylindrical lens.

13. A device according to Claim 12 wherein the cylindrical lens can be pivoted about a longitudinal axis perpendicular to the optical axis.

14. A device according to any of Claims 11 to 13 wherein at least one mirror element is provided between the light source for the lower light and the surface.

15. A device according to any preceding Claim wherein the lower light and/or the upper light emits diffuse light.

16. A device according to Claim 1 wherein the lower light comprises optical means which have at least one lens

arrangement in order to concentrate the light emitted by the light source for the lower light in such a way that the surface can be illuminated from only one side of the object with a substantially constant light intensity starting from the edge facing the lower light to the edge of the surface facing away from the lower light.

17. An optical testing device substantially as described herein with reference to the accompanying drawings.

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Application No: GB 9606311.0
Claims searched: 1

Examiner: Andrew Alton
Date of search: 1 July 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1A: AAJF,AAJP,AMBP,AMBX,ATH

Int Cl (Ed.6): G01B: 11/30; G01M: 11/00; G01N; 21/88

Other: Online database: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 4929081 YAMAMOTO - See Fig. 1	1,3,5,10

X Document indicating lack of novelty or inventive step
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